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ABSTRACT

An hypothesis concerning a definition of the concepts assimilation and accommodation was tested. Both assimilation and accommodation were hypothesized to be processes that produce changes in cognitive structures--internal representations used to organize behavior. The hypothesis is that, in contrast to assimilation, the changes in structure caused by accomodation are only partially reversible. The experiment was a multidimensional scaling procedure repeated three times to reproduce walking distances between buildings on a familiar college campus. The second time, the students in the assimilation condition estimated distances between additional buildings, whereas the students in the accommodation condition were asked to estimate distances as though an imaginary barrier blocked the middle of the campus. The third time, the students were asked to reproduce their original estimates. The results showed that the accommodation condition had a statistically significant effect on the judgments made on the third trial, thus supporting the hypothesis that accommodation produces changes in cognitive structures that are not fully reversible. (CTM)

RM-76-5

RESEARCH MEMORANDUM

THE IMPACT OF MENTAL MANIPULATIONS ON COGNITIVE STRUCTURES

Michael P. Ryan

This paper was presented at the Annual Meeting of the Eastern Psychological Association, New York City, April 1976.

Educational Testing Service
Princeton, New Jersey
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The Impact of Mental Manipulations on Cognitive Structures[1]

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Princeton, New Jersey

An important premise underlying the distinction between assimilation and accommodation is that in assimilation the acquisition of certain kinds of information merely elaborates existing cognitive structures whereas in accommodation the acquisition of other kinds of information significantly reshapes existing cognitive structures. Such a notion is intrinsic to many accounts of cognitive development since it provides a specifiable mechanism for cognitive change. However, the accommodation hypothesis--that the distortion of cognitive structure through the acquisition of incongruent data results in enduring cognitive change--has never been tested directly: Internal representations are not easily quantified, and distortions of their structure are not readily devised. The work I will be presenting here represents an attempt to conceptualize the accommodation hypothesis more precisely and to provide a demonstration of the process that may underlie the phenomenon of accommodation.

I believe that there are three kinds of assumptions that are needed to construct a viable model of the process of accommodation. One must decide what initiates the process, what the process involves, and what its outcome is. Let me consider now the first question. Cognitive structures are internal representations that an individual uses to organize his behavior in particular situations. One claim implicit in the accommodation hypothesis is that the

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structure of an internal representation can be incompatible with the structure of the environmental or task setting and that it is this noncorrespondence of structure that initiates the process of accommodation. One precise way of defining such a state is by the incongruity that results when the geometry of an internal psychological structure does not correspond to the geometry of an external reality structure. This state can be realized experimentally if one studies cognitive maps that individuals have of familiar terrains. Geometric incongruity can be obtained by the simple expedient of inserting a barrier in the terrain represented by a given cognitive map. The traveling time and distance between various pairs of landmarks will then be systematically distorted by the need to detour around the barrier. On the other hand, a different, although geometrically congruent, cognitive map results from adding some new landmarks to the terrain and removing some old ones. Thus, by adding a barrier to a terrain, one can simulate the structural incongruence thought to promote processes of accommodation, and by modifying the landmark composition of that terrain, one can simulate the structural congruence thought to characterize processes of assimilation.

Given that we have defined what we mean by structural incompatibility, how can we describe what goes on in the process that it is said to initiate? It must be assumed first that there is some pressure for an individual to encode a structure which is incongruent with an internal representation he already possesses. If he is to encode that structure, then he can only do it by applying a sequence of transformations to his most appropriate representation in order to construct an approximation of the required structure. I want to suggest that the crux of the accommodation hypothesis is the suggestion that when such transformations involve distortions of structure, it is not wholly possible to reverse the construction process so as to

recover the original representation. Thus accommodation can be said to occur wherever the task-imposed transformations of an existing cognitive structure are only partially reversible; assimilation is said to occur wherever the transformations are completely reversible.

It is now appropriate to consider how the outcome of the accommodation process might be measured. What is important to realize in this context is that the proposition that the structure of an internal representation has been reshaped implies that the original representation is no longer available. As such, if we ask an individual who has constructed a representation incongruent with an earlier one to reproduce his initial representation, the representation he recalls should be structurally different from the actual representation he brought to the situation. We can measure the amount of accommodation a given internal representation has undergone by measuring the degree to which the discrepancy between pre- and post-transformation representations can be predicted from a knowledge of the distortions that the transformational construction imposed upon the original representation. Any acceptable test of the accommodation hypothesis must, therefore, involve a detailed examination of a particular internal representation before and after it has been subjected to a quantifiable transformation of structure.

The logic of the actual experiment is then quite straightforward: I want to ask individuals to encode the incongruent cognitive map required for barrier detours or to encode the congruent cognitive map required for the addition and deletion of landmarks. Next I need to demonstrate that the encoded structures are in fact incongruent or congruent with respect to the initial landmark configuration. Support for the accommodation hypothesis will then consist in

the demonstration that there are distortions in a subject's recollection of the initial spatial representation which can only be attributed to having performed the incongruity-producing barrier transformation.

Procedure

The landmark configuration consisted of 13 prominent buildings on the Stanford University campus, and the subjects were 27 undergraduates who had lived on campus six months or more. Each undergraduate provided an initial description of the relative locations of these landmarks by rank-ordering a deck of index cards in which each pair of landmarks was named on a separate card. Subjects were instructed to rank the cards according to their estimates of the relative size of each interlandmark trip. They were further instructed that their estimates should be of the shortest possible walking distance in each case.

The barrier manipulation in the accommodation condition involved the description of an imaginary barrier down the middle of the campus (dashed line in Figure 1) and instructions that the deck of trip cards now be ordered

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Insert Figure 1 about here

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so as to take account of the increased length of those trips requiring detours around the barrier. The substitution manipulation in the assimilation condition was accomplished by replacing five old landmarks with five new ones and providing a new deck of trip cards to be rank ordered. (Elements in this modified configuration are indicated by open circles in the figure.) Finally, subjects in both conditions were instructed to recover their original representations of the landmark configuration by reproducing their initial rank-ordering as accurately as possible.

Results

The first data question is whether subjects actually transformed their internal representations as instructed. A multidimensional scaling procedure was used to produce spatial representations of the rank-order data provided by individual subjects. Figure 2 shows the landmark configuration

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Insert Figure 2 about here
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on the detour trial superimposed upon the configuration from the initial trial for 12 subjects in the barrier condition. The darkened circles represent landmark locations on the detour trial, and the associated line segments indicate the degree and direction of displacement of the landmark from its original location. It is apparent that the barrier distorts the two-dimensional structure of the configuration by forcing landmarks into clusters on either side of the barrier. The barrier transformation is thus producing the kind of structural incongruity that we have associated with the process of accommodation.

Using the same scaling procedures, we can superimpose the spatial representation from the substitution trial upon the configuration from the initial trial for 15 subjects in the substitution condition. Figure 3 shows

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Insert Figure 3 about here
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that the two spatial representations fit together rather well. The darkened circles in this case identify landmarks in the original configuration while the open circles identify landmarks in the configuration in which substitutions have been made. Corresponding landmarks in each map are connected by line segments. You will note that the eight landmarks common to both configurations are located in approximately the same position in each spatial

representation. It is this correspondence of psychological structure that suggests that substitution transformation involves a process of assimilation rather than accommodation.

Given that the scaling analyses show that the two experimental manipulations were successful, we can now consider the critical data question: Can discrepancies between a subject's original rank-ordering of inter-landmark distances and the rank-ordering he recovers subsequent to the barrier transformation be attributed to the enduring impact of that transformation? The accommodation hypothesis, as it has been formulated here, predicts that they can. If there has been no accommodation of the original cognitive map to the momentary presence of the barrier, then the difference between the pre- and post-barrier ranking of a trip which involved a detour ought to approach zero. However, if the original map has been somewhat reshaped by the constructive encoding of the barrier, then a knowledge of the barrier transformation should enable us to predict these discrepancy scores with some degree of accuracy. In fact, the barrier transformation can be quantified rather easily. We simply determine by actual measurement the normal and detour rank that an ideal subject would provide and we can then calculate the change in rank that would be expected for each trip involving a barrier detour. There are 40 such trips and the s[redacted] of 40 ideal change scores represents a rather precise description of the transformation imposed by the barrier. Thus, in order to provide support for the accommodation hypothesis, we need only show that we can predict the difference between pre- and post-barrier ranks of detour trips from our knowledge of the changes in ranks that an ideal subject would have made in responding to the barrier manipulation.

The median difference between initial and final ranks of detour trips was computed for the 12 barrier subjects and plotted against the ideal change scores that characterize the barrier transformation. As shown in Figure 4,

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Insert Figure 4 about here

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the slope of this line measures the residual or enduring effects of the barrier transformation with respect to the amount of change induced by the actual presence of the barrier. The linear regression in this instance is significant at the .05 level. This result indicates that, having restructured their cognitive maps, barrier subjects were subsequently unable to recover their original landmark representations intact. Furthermore, if we interpret the slope as a measure of the degree of accommodation, we can conclude that for every six units of change involved in the barrier transformation, there is approximately one unit of transformational residue in the post-barrier maps.

In contrast, the median difference between the initial and the final ranking of each substituted trip in the assimilation condition does approximate zero. These medians have been plotted against the ideal values characteristic of the substitution transformation in Figure 5.

Insert Figure 5 about here

The constructive encoding of the modified landmark set did not produce any enduring change in the cognitive maps of substitution subjects. This result is just what one would expect in a condition simulating the process of assimilation.

Discussion

The important finding in this set of data is that a significant portion of the observed discrepancy between the initial and the final representation of the landmark configuration in the detour condition can be predicted from a knowledge of the barrier transformation. No such transformational residue is detectable in the substitution condition. These data demonstrate that some transformations of internal representations are relatively irreversible in the sense that the transformed representation cannot be immediately restored to its original form. Since the barrier transformation appears to differ from the substitution transformation in the computational effort it demands and in the amount of change it engenders, as well as in its structural impact upon the initial representation, it is not possible at this point to determine exactly why the barrier transformation is more reactive than the substitution transformation. However, it is clear that the results provide a direct test of one version of the accommodation hypothesis and that the phenomenon is more powerful than might have been anticipated. We know that it must be powerful because the internal representation a student has of campus landmarks is based on a good deal of past experience and is important for much of his daily routine: a cognitive structure of this sort is not likely to be reshaped by inconsequential variables.

Now that a model of the accommodation process has been formulated, it becomes of interest to ask whether the process is different for children than it is for adults. A popular assumption would be that accommodation occurs more often in the cognitive lives of children than it does in adults,

but such a proposal needs to be examined carefully. Since children may well have a smaller repertoire of cognitive structures, accommodation may be more evident in their mental activities simply because they are more often required to transform these structures in response to the task demands of their environments. On the other hand, the internal representations of children may actually be more plastic under any sort of transformation--that is, the slope of the transformational residue equation may be much larger for them than for adults. Such malleability might be the case because children happen to transform their underlying representations while adults tend to create working copies on which to perform their transformational computations so as to avoid distortions of the original representation. Thus the model of the accommodation process I am proposing here raises some intriguing research questions. But I believe that the real value of this conceptualization is that it provides a more elegant description of assimilation and accommodation than has so far been possible. As such, it should aid us to develop more elegant answers to issues that have been of central concern to developmental psychologists.

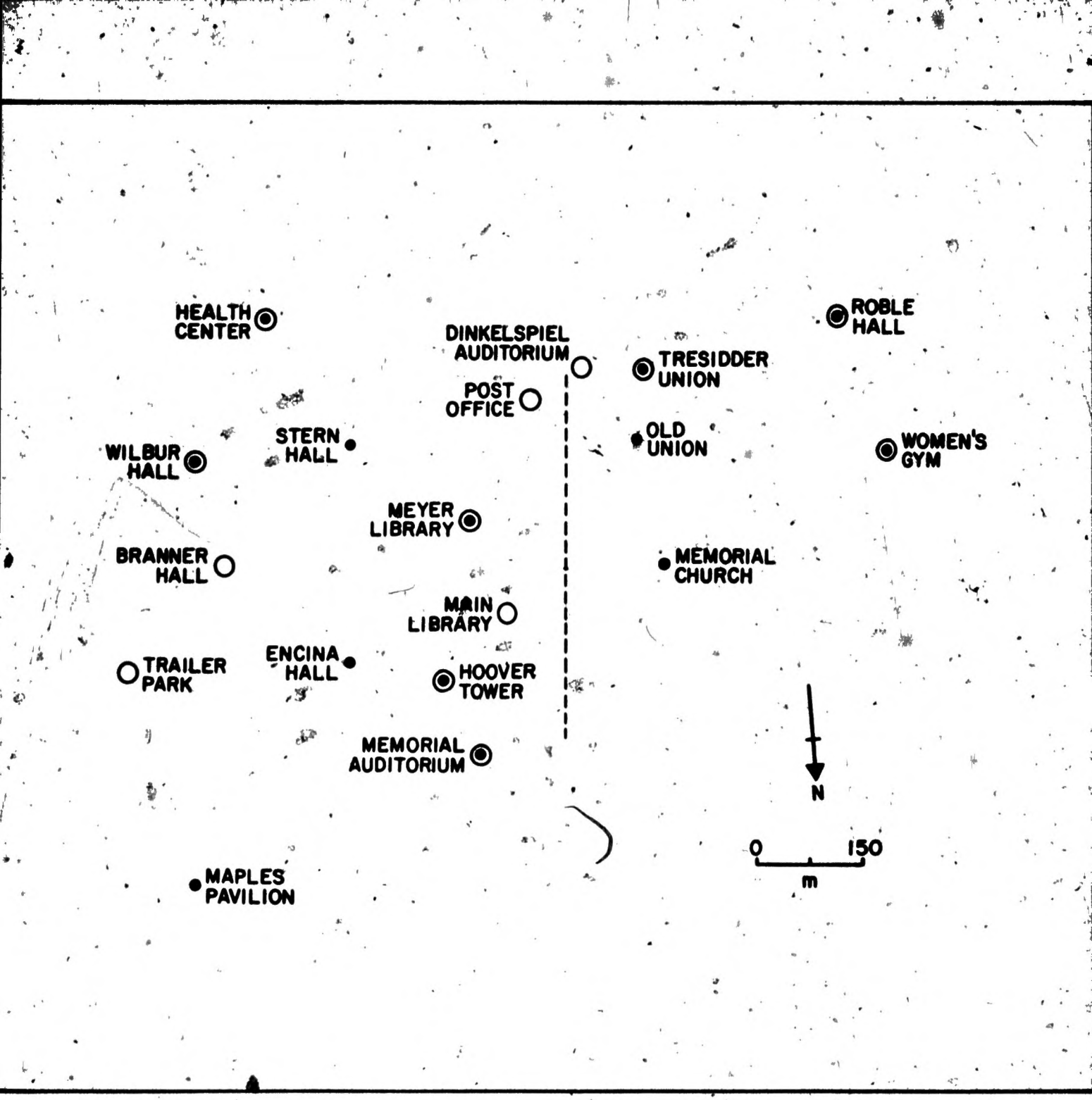
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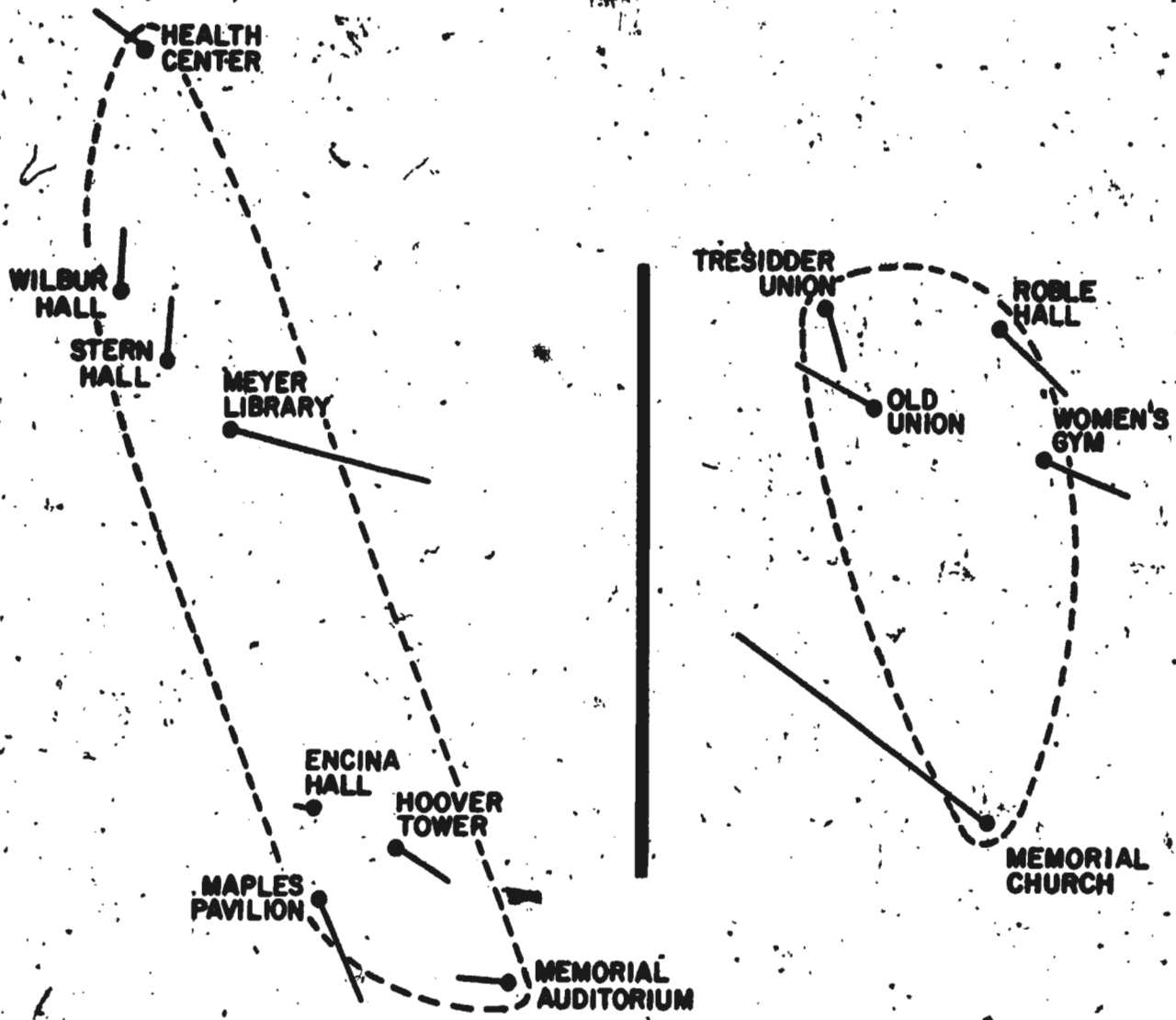
Figure 1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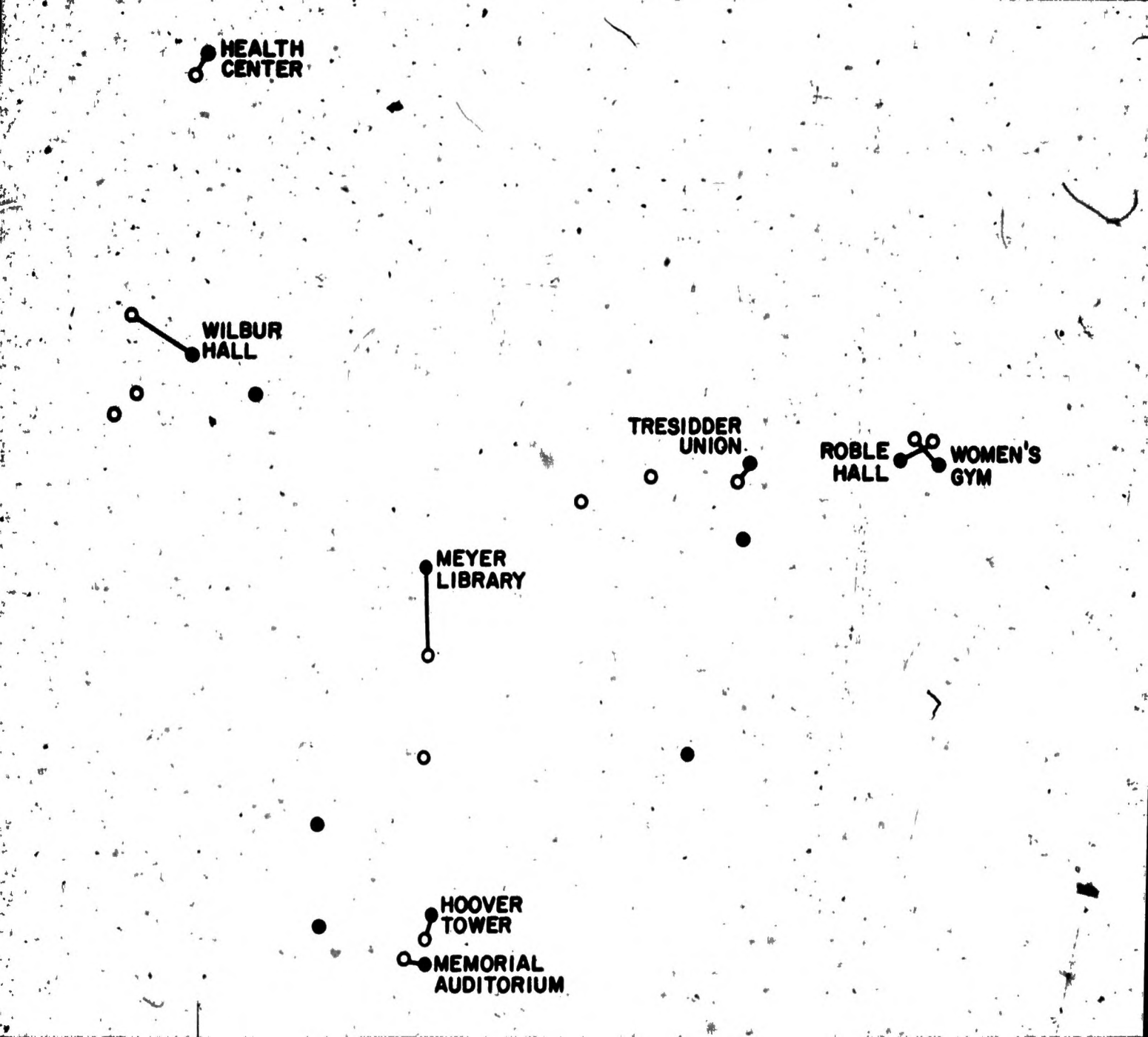
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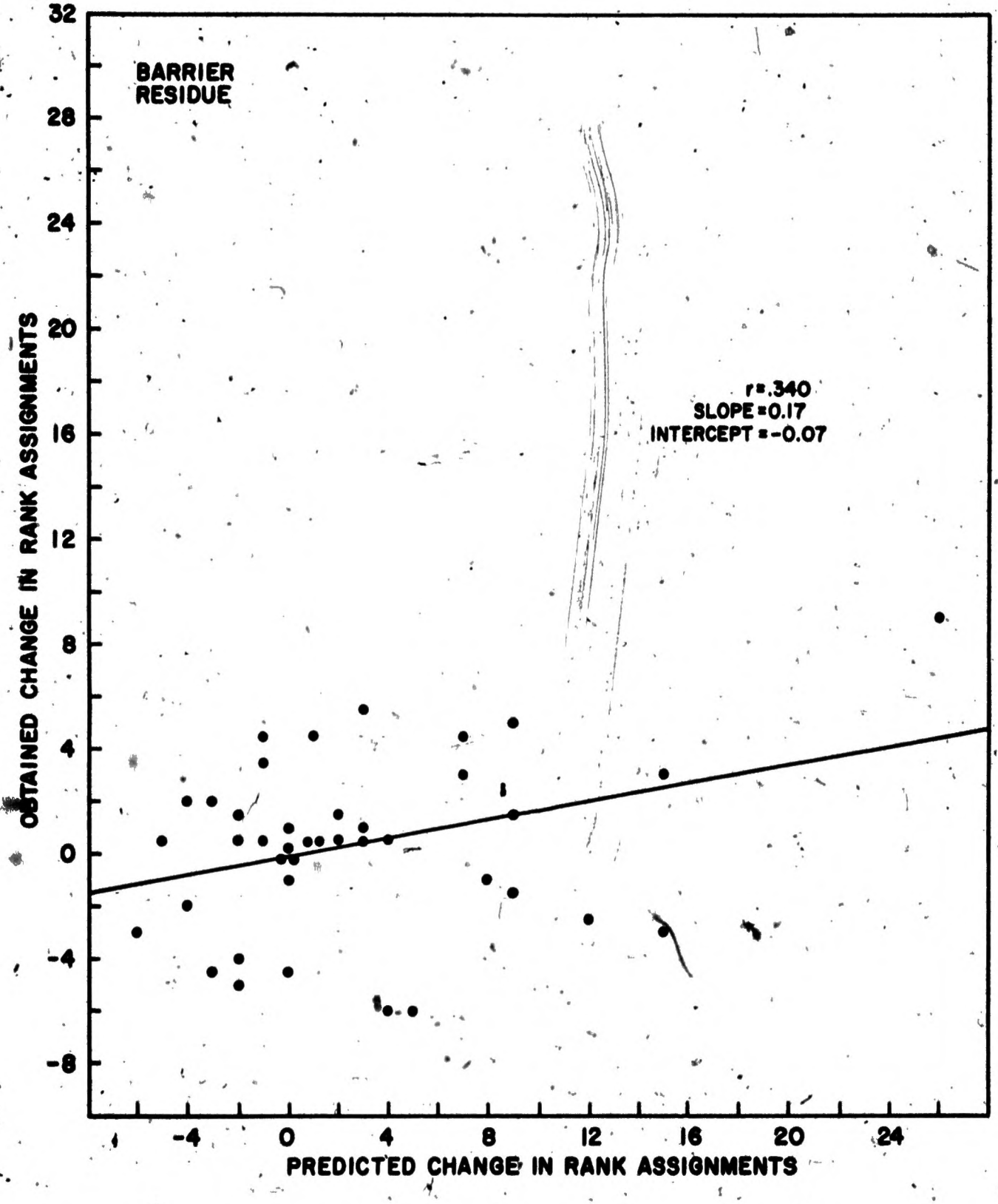
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Figure 4

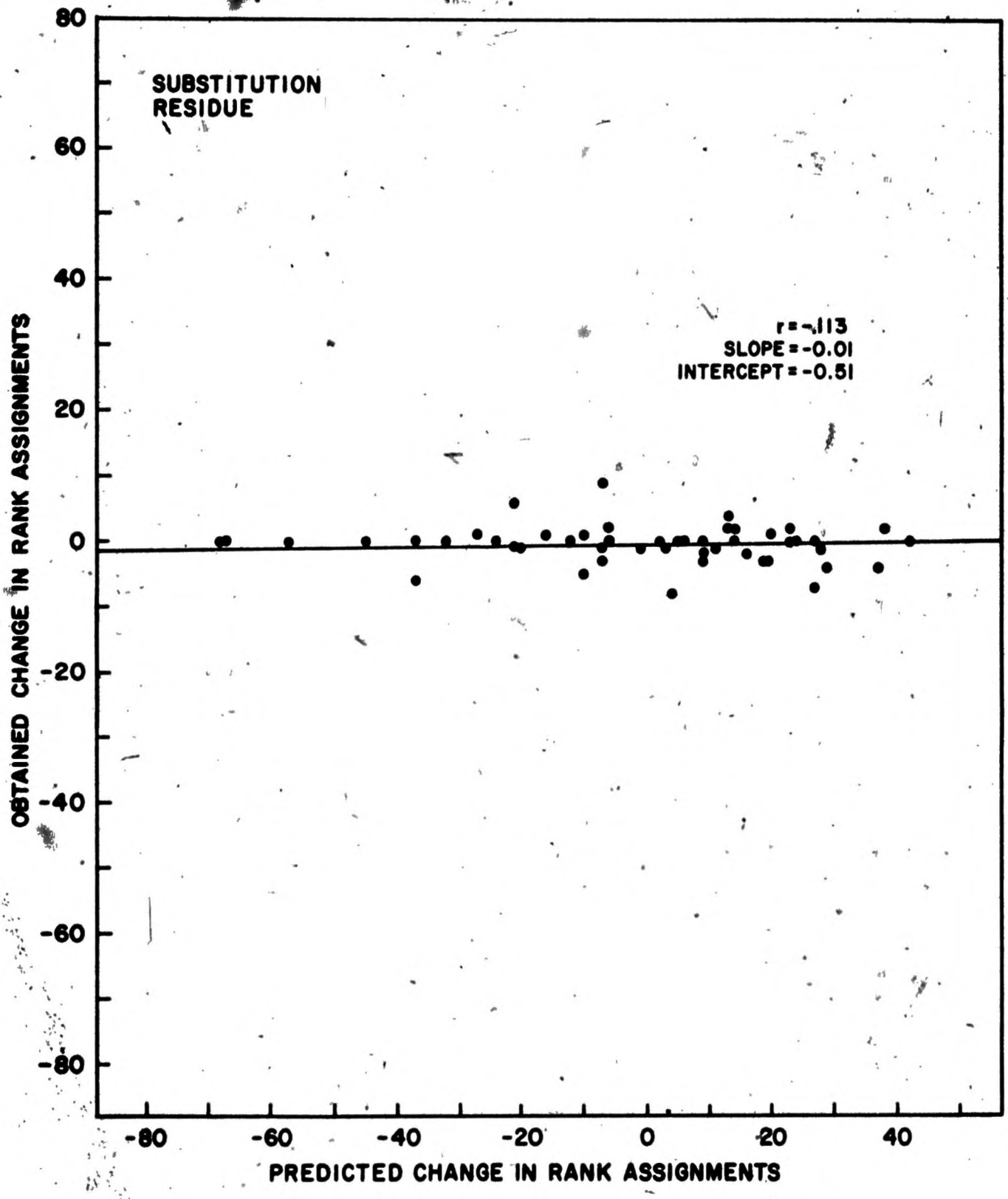
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Figure 5